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Sleep duration associated with body mass index among Chinese

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Running title: sleep duration and body mass index

Highlights

- short sleep is common in china
- Sex modify sleep-obesity
- Short sleep increased obesity in men

Abstract

Objective: To investigate the relationship between sleep duration and obesity among Chinese adults.

Methods: A community-based cross-sectional study was conducted among Chinese adults in 2008. In total, 3,225 participants were selected by a multistage cluster sampling method. Self-reported sleep duration was measured by a standardized questionnaire. Logistic regression models were used to estimate the odds ratios (95% CIs) of obesity with sleep duration, separated by gender, and adjusted for age, education, occupation, marriage, smoking, drinking, body pain, and health status.

Results: Mean sleep duration was 7.8 hours. Among the 2,962 participants, 7.2% had short sleep duration (≤ 6 hours/day). There were 171 obese participants (5.7%) in this population. After adjustment for age, short sleep duration (< 6 hours) was significantly associated with obesity among men (OR: 2.15, 95% CI: 1.19–3.90), but not among women; additional adjustment for potential confounders did not attenuate the association among men. Increasing sleep duration (a continuous variable) was significantly and negatively associated with obesity in women after adjustment for education level, occupation, marital status, smoking, drinking, body pain, and health status. The adjusted OR per hour increase in sleep duration was 0.74 (0.56-0.97) for obesity, suggesting that for a one-hour increase in sleep duration among women, obesity risk decreased by 26%.

Conclusion: Short sleep duration was associated with increasing obesity in Chinese men, and sleep duration was associated with obesity in Chinese women, although the underlying mechanism is unclear. This possible gender difference warrants further studies.

Keywords: Sleep duration, BMI, Obesity, Chinese

Introduction

Obesity is an important public health issue in China. According to the Chinese National Survey, 23.2% of Chinese adults had either overweight or obesity [1]. Obesity has been shown to be associated with increased risk of mortality and fatal health outcomes such as cancer and cardiovascular disease [2, 3]. Although the evidence for an association of sleep duration and obesity in children is stronger [4-7], the association may also exist among adults. For example, Gildner et al. conducted a cross-sectional study by using nationally representative datasets from six countries and found that shorter sleep duration in both men and women is significantly associated with higher BMI in older adults (>50 years)[8].However, longitudinal evidence is less conclusive[7] [9, 10].

Moreover, the sleep-obesity association may vary across race and gender groups [11-13]. There is a need to examine the associations in an Eastern population given differences in sleep patterns[14], body composition [13], and other relevant lifestyle/sociocultural factors; these differences could mean the sleep-obesity relationship varies by culture. In addition, it is conceivable that occupational stress and eating habits, which may underlie the sleep-obesity relationship, differ significantly across countries/race groups[15]. Most studies which examined this issue were conducted in a Western setting; data on Eastern settings are scarce [16, 17]. In addition, Xiao et al. observed a gender difference in the relationship between sleep duration and body mass index (BMI) in a cohort of 83,377 American adults aged 51-71 years [11]. To our knowledge, there is no evidence regarding gender differences among Eastern populations.

In this study, we investigated the relationship between sleep duration and obesity indexed by BMI in a large community-based sample from the general Chinese population. We also examined whether these associations varied by gender.

Methods

Participants

A random multistage cluster sampling method was used to select the study population in Beijing (China's capital city) from Apr. to Oct. 2008. The city was classified into urban and suburban areas according to administrative subdivisions. We randomly selected one urban district (Chong wen) and two suburban districts (Tongzhou and Lucheng) as the study fields to represent both urban and suburban populations. In each field, college students, local residents, local government staff, and workers were cluster-selected. In total, 3,800 participants aged 18 to 55 years were included. We excluded those younger than 16 or older than 65 years. We also excluded shift workers or those with diseases (e.g. depression and insomnia) which could have an effect on sleep duration. There were 2,981 participants that remained in the final analysis. Data on demographic characteristics, medical history, time to fall asleep, sleep time, sleep efficiency, drug use, etc. was obtained via a self-administered standard questionnaire and overseen by trained study investigators.

BMI

Based on recommendations from the Working Group on Obesity in China [18], BMI was categorized as follows: underweight: <18.5; normal: 18.5-23.9; overweight: 24.0-27.9; obese: ⩾ 28. The normal group was used as the reference group. The cutoff point for obesity was 28.

Sleep-timing

We used the modified Pittsburgh Sleep Quality Index to measure the timing of sleep. The questionnaire was translated into Chinese for use in this study population [19]. Participants reported their time going to bed and the time of arising. Sleep duration was calculated according to the following equation: sleep duration = (preferred arising time + 24) − (preferred going to bed time).

Statistical Analysis

SAS for Windows Statistical Software Package Version 8.2 (SAS Institute, Cary, NC, USA) was used for data processing and analysis. Obesity was analyzed as a binary outcome variable and sleep duration, categorized into five groups (< 6, 6-7, 7-8, 8-9, and ⩾ 9 hours), was investigated as a categorical variable. Chi-square tests were used to compare participants' characteristics by BMI. Logistic regression models were applied to estimate the odds ratios and 95% CIs of obesity by sleep duration adjusted for potential confounders. Men and women were presented separately because of gender differences in sleep duration. Two sets of potential confounders were used in the adjusted models. Model 1 was adjusted for age. Model 2 was further adjusted for education level, occupation, marital status, smoking, drinking, body pain, and health status. Health status was assessed by self-reported chronic illness including: hypertension, diabetes, coronary heart disease, hypercholesterolemia, hepatitis, and others. Participants with any of the above chronic diseases were categorized as unhealthy. All potential confounders are summarized in Table 1. All the tests were two-sided and the significance level was set at 0.05.

The study was approved by the Ethics Committee, Beijing Union Medical College University and followed the tenets of the Declaration of Helsinki. Written informed consent was obtained from all participants after the nature of the study was explained.

Results

Of 2,981 participants, 19 were excluded because of missing information on potential confounders and, 2,962 (1,344 men and 1,618 women) were included in this analysis. Among the 2,962 participants, there were 171 participants (5.74%, 95% CI: 4.90%–6.58%) with obesity (111 men [8.26%, 95% CI 6.79%–9.73%] and 60 women [3.71%, 95% CI 2.79%–4.63%]).

The average sleep duration (mean ± SD) was 7.75±1.06 hours for men, 7.84 ± 1.04 hours for women, and 7.80 ± 1.05 hours for all. Approximately 67.06% of study participants reported normal daily sleep duration (6-8 hours), 7.15% reported short sleep duration (⩽ 6 hours/day), and 25.80 % reported long sleep duration (⩾8 hours/day).

Table 1 shows that obesity was more common among those who reported short sleep duration; were older; or were in poor health.

We have tested the interaction between genders and sleep duration in the association with obesity. The p value for interaction was 0.02, suggesting the sleep-obesity association was modified by gender. Table 2 shows that in Model 1, after adjusting for age, short sleep duration (< 6 hours) was significantly associated with obesity among men but not among women. In Model 2, additional adjustment for education level, occupation, marital status, smoking, drinking, body pain, and health status did not attenuate the association, such that short sleep duration remained significantly associated with obesity (OR: 2.15, 95% CI: 1.19–3.90) among men.

Table 2 also shows that sleep duration (a continuous variable) was negatively associated with obesity in Model 1 in both men and women. After further adjustment for education level, occupation, marital status, smoking, drinking, body pain, and health status (Model 2), the association among men for obesity was not statistically significant, but was significant in women, where the adjusted OR per hour of sleep duration was 0.74 (0.56-0.97) for obesity, suggesting that for a one-hour increase in sleep duration among women, obesity risk decreased by 26%.

Discussion

In this large, community-based study, short sleep duration was associated with obesity in men, while longer duration was associated with obesity in women, after adjusting for demographic characteristics, lifestyle factors, and health status. These results suggested that the negative association of sleep duration with obesity may be partly explained by other risk factors, with perhaps the clearest evidence of an independent role for short sleep duration, where the associations were consistent among men and women.

The most salient finding of our study was the sex differences in the relationship between sleep duration and obesity. Of note, our results indicated that the association was modified by gender. Previous studies observed that gender was an effect modifier of the association between short sleep duration and overweight among children[20]. A possible explanation is that females cope better with environmental stress, and thus they would need a much shorter sleep duration to put them at risk of overweight or obesity [21, 22]. As reported in the results, the prevalence of obesity is lower in females than in males which could partially explain the difference. Furthermore, it is possible that BMI is not a good measure of body composition in Chinese females. If this is the case, it may suggest that the absence of a result in females is due to

measurement issues. Future studies with accurate body composition measurements, e.g. dual-energy x-rays, are needed to further elucidate the directionality of these complex interactions.

Our results were in line with a previous study reporting that shorter sleep duration was associated with increasing BMI: Xiao et al. followed a cohort of 83,377 US men and women aged 51-72 years, and prospectively investigated the association between self-reported sleep duration and weight change over an average of 7.5 years of follow-up (1995-2004).They reported that people with shorter sleep duration had a significant high risk of developing obesity[11].

However, Vgontzas et al. used a cohort study and posited that self-reported short sleep duration in non-obese individuals at risk of developing obesity was a surrogate marker of emotional stress and subjective sleep disturbances[23]. Vgontzas et al. used objective measures of sleep (unlike most previous studies) and used the criterion of ≥7 hours as the cutoff point for 'normal' sleep duration and defined obesity as a BMI ≥ 30. Of note is that the relationship between sleep duration and obesity could be a J shape or U shape[24].

Our results did not confirm that longer sleep duration was associated with obesity. Nagai et al. conducted a study among community-dwelling Japanese subjects and observed no association between sleep duration and obesity. After stratification by BMI, long sleepers had a significantly increased risk of ⍰5kg weight gain (OR: 1.36, 95%CI: 1.09-1.70) among obese participants. They concluded that only obese long sleepers had a significantly increased long-term risk of ⍰5kg weight gain [25]. A plausible explanation is that longer sleep duration could reduce physical activity and the intake of calories. However, there were national/race differences among sleep duration [26, 27], as well as BMI.

Although there are many explanations for the association between short sleep duration and increased BMI in adolescents over time[28], there is not convincing evidence to support such a relationship in adults [9]. School children and adolescents have a different sleep model than adults (reference), which is highly related to school schedule. Of note, children's BMI varies due to their rapid growth. Moreover, Chaput et al. pointed out that the sleep-body fat relationship becomes progressively less detectable with increasing in age [29].

A potential explanation is that short sleep duration may be an important indicator of poor sleep quality in obese persons. However, poor sleep quality was not shown to be associated with BMI [30]. An alternative possibility is that sleep pattern, which was associated with sleep duration, could have an effect on obesity. Baron et al. conducted a study on sleep timing on dietary patterns and BMI among 52 participants and found that a later sleep pattern (midpoint of sleep ⩾5:30 AM) is a contributor to obesity. They also pointed out that later sleepers have a shorter sleep duration and consume more calories after 8:00 PM [31]. Moreover, dietary patterns may also be involved in the sleep-obesity relationship, e.g. a recent study found that the percentage of energy from protein consumed at a buffet meal increased following short sleep[32].

Limitations

Our study data was based on self-reported questionnaires, which might not result in accurate measurements of sleep duration and BMI. However, there was no evidence that obese people tend to report shorter sleep duration. Thus, the measurement error is more likely to be random, and our large sample size could partly compensate for it. Second, information on physical activity was not available in the present study. Previous studies have reported that physical activity showed no effect on sleep duration in middle-aged or old respondents[33]. In our study, the occupation of the participants was adjusted in the analysis models, which can partly control for physical actively Given that the physical activity level of most Chinese adults was highly related with occupation [34]. However, further studies taking into account these potential confounders are necessary. Third, residual confounding, e.g. diet [35], geography, and environmental factors [36, 37] etc., might also partly affect the results.

Conclusion

Short sleep duration was associated with increasing obesity in Chinese men, and a per-hour increase in sleep duration was associated with obesity in Chinese women, although the mechanism is unclear. However, the associations were not consistent by gender, suggesting these associations could be non-causal. Replication using stronger study designs is needed.

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Author Contributions

Conceived and designed the experiments: T.X; G.S; W.S;

Performed the experiments: T.X; G.S

Analyzed the data: W.S

Wrote the paper: T.X; W.S

Conflicts of Interest

The authors declare no conflict of interest.

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Table 1. Demographic characteristics of Chinese adults in Beijing (column %)

	Men (n=1,344)					Women (n=1,618)				
	<18.5 (n=59)	18.5-24 (n=758)	24-28 (n=416)	≥28 (n=111)	Obesity prevalence (BMI>28)	<18.5 (n=212)	18.5-24 (n=976)	24-28 n=(370)	≥28 (n=60)	Obesity prevalence (BMI>28)
Sleep duration (hour)*										
<6	9.09	6.10	10.80	17.27	17.12	6.63	6.29	5.25	13.79	8.08
6-7	10.91	18.86	27.64	20.91	8.36	19.39	21.00	25.69	24.14	4.09
7-8	47.27	49.93	42.21	40.00	7.36	36.73	43.92	47.24	43.10	3.68
8-9	9.09	8.32	6.28	7.27	8.16	11.73	9.06	5.80	5.17	2.27
≥9	23.64	16.78	13.07	14.55	7.92	25.51	19.72	16.02	13.79	2.66
Age (years)*										
≤ 25	52.73	46.32	19.35	20.00	4.76	42.35	30.38	15.19	1.72	0.24
25-≤45	30.91	36.89	46.98	49.09	10.31	44.90	51.17	50.55	43.10	3.22
45-≤65	16.36	16.78	33.67	30.91	11.41	12.76	18.44	34.25	55.17	9.04
Education*										
Literate/primary school	20.00	34.4	15.58	7.27	2.43	10.20	22.07	38.12	37.93	5.68
High school	20.00	19.28	19.6	20.91	9.16	14.29	13.97	16.02	18.97	4.82
College	60.00	46.32	64.82	71.82	11.22	75.51	63.97	45.86	43.10	2.66
Occupation*										
Civil	16.36	14.29	32.91	41.82	15.92	15.82	19.94	25.41	27.59	4.91
Professional	16.36	14.56	18.84	15.45	8.25	33.16	27.93	24.31	17.24	2.35
Worker	10.91	7.21	8.79	6.36	7.00	3.57	3.84	3.31	1.72	1.79
Famer	3.64	24.55	6.03	0.91	0.49	4.59	13.97	30.66	32.76	7.04
Business/service	18.18	17.2	18.09	19.09	9.25	18.37	17.06	8.56	15.52	3.81
Student	29.09	15.26	9.8	10.91	6.78	19.9	8.42	1.10	0.00	0.00
Other	5.45	6.93	5.53	5.45	7.41	4.59	8.85	6.63	5.17	2.52
Marital status*										
Single	67.27	51.04	26.13	28.18	5.74	53.06	38.49	16.3	3.45	0.38
Married	27.27	47.99	70.6	70.91	10.83	43.88	60.13	80.66	93.1	5.42
Divorced/Widowed/Separated	5.45	0.97	3.27	0.91	4.17	3.06	1.39	3.04	3.45	6.25
Smoking*										
No	60.00	58.95	53.02	41.82	6.43	96.43	98.61	98.9	96.55	3.66
Yes	40.00	41.05	46.98	58.18	11.25	3.57	1.39	1.10	3.45	7.69
Drinking*										
No	60.00	61.03	46.73	39.09	6.13	90.31	91.15	90.61	94.83	3.89
Yes	40.00	38.97	53.27	60.91	11.51	9.69	8.85	9.39	5.17	2.16
Body pain*										
Yes	70.91	79.75	66.58	70.91	8.15	62.24	65.88	64.36	63.79	3.66
No	29.09	20.25	33.42	29.09	9.79	37.76	34.12	35.64	36.21	3.86
Healthy*										
Yes	87.27	89.04	74.37	50.00	5.28	89.8	90.62	81.77	65.52	2.79
No	12.73	10.96	25.63	50.00	22.63	10.20	9.38	18.23	34.48	10.31

*P for the test <0.05

Table 2. Adjusted odds ratios (95% CIs) for the association of sleep duration with obesity by gender

	Men			Women		
	n	Model 1§	Model 2ǂ	n	Model 1§	Model 2ǂ
Sleep duration (Hours)						
<6	111	2.47 (1.37-4.45) *	2.07 (1.10-3.90) *	101	1.67 (0.72-3.92)	2.02 (0.80-5.08)
6-7	285	1.05 (0.62-1.79)	0.87 (0.49-1.52)	352	0.90 (0.46-1.77)	1.11 (0.55-2.25)
7-8	631	Ref.	Ref.	718	Ref.	Ref.
8-9	103	1.09 (0.49-2.40)	0.95 (0.42-2.17)	133	0.58 (0.17-1.98)	0.61 (0.17-2.12)
≥9	214	1.22 (0.67-2.24)	1.65 (0.85-3.21)	314	0.99 (0.44-2.27)	0.78 (0.33-1.87)
Per hour		0.85 (0.71-1.02)	0.97 (0.80-1.19)		0.84 (0.65-1.09)	0.74(0.56-0.97) *

§Model 1 adjusted for age;

ǂ Model 2 adjusted for age, education, occupation, marital status, smoking, drinking, body pain, and health status

*P <0.05